

ASHRAE/IESNA Standard 90.1-1999

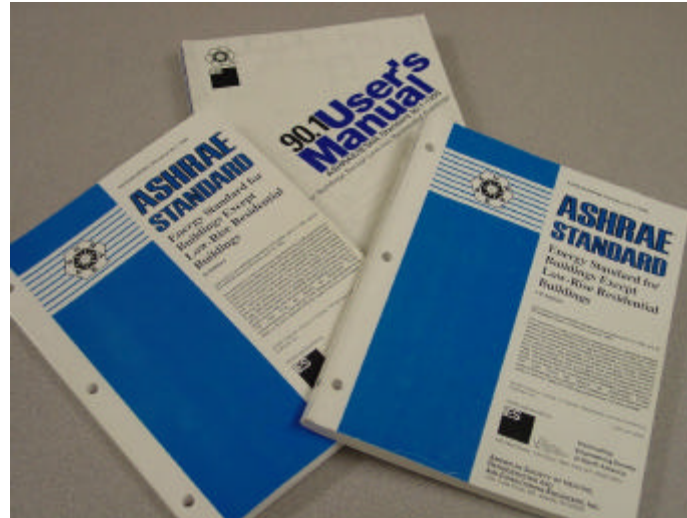
## **Mechanical Requirements**

**Mick Schwedler, P.E.**

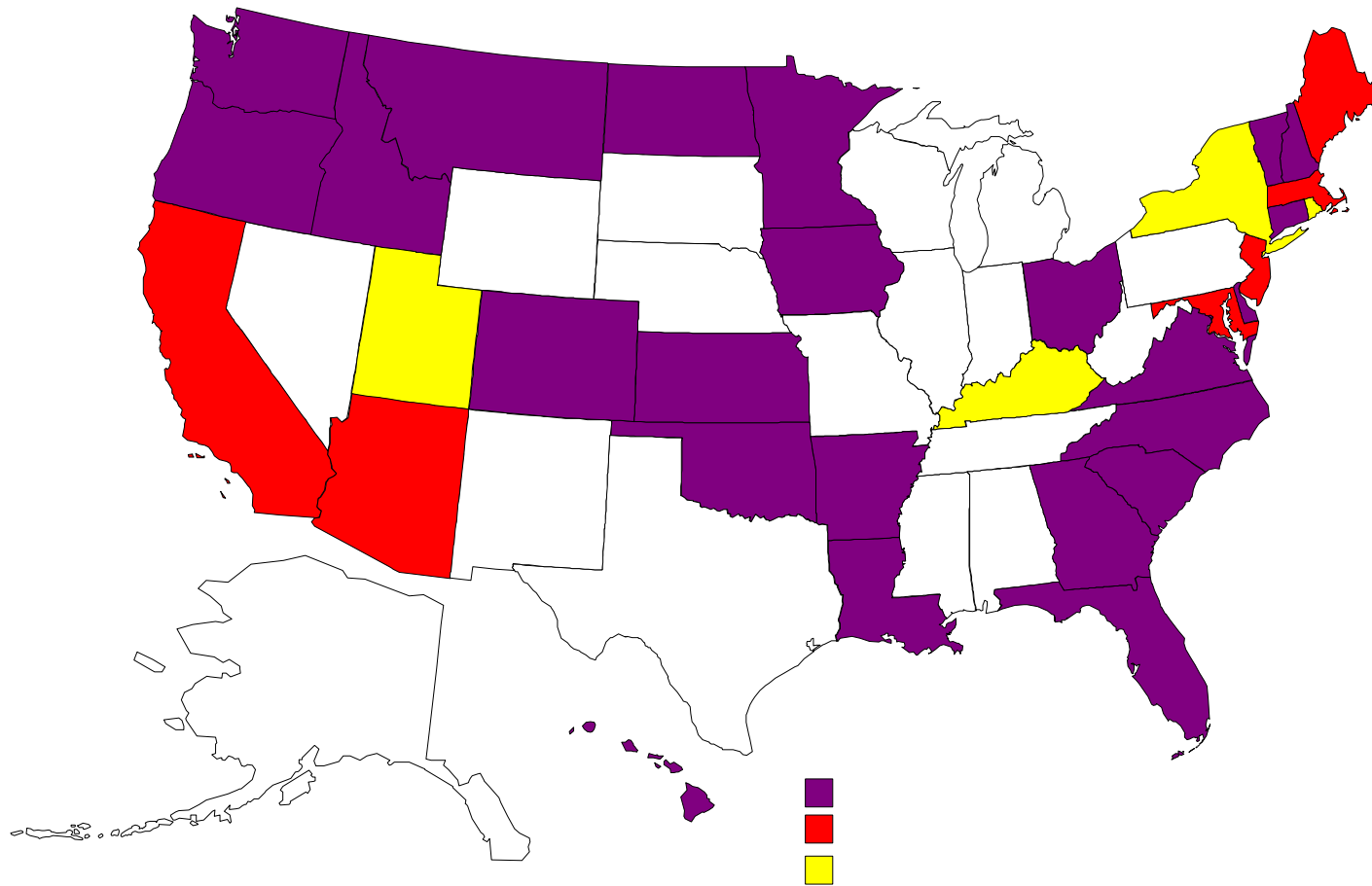
The Trane Company

Past Member of ASHRAE SSPC 90.1

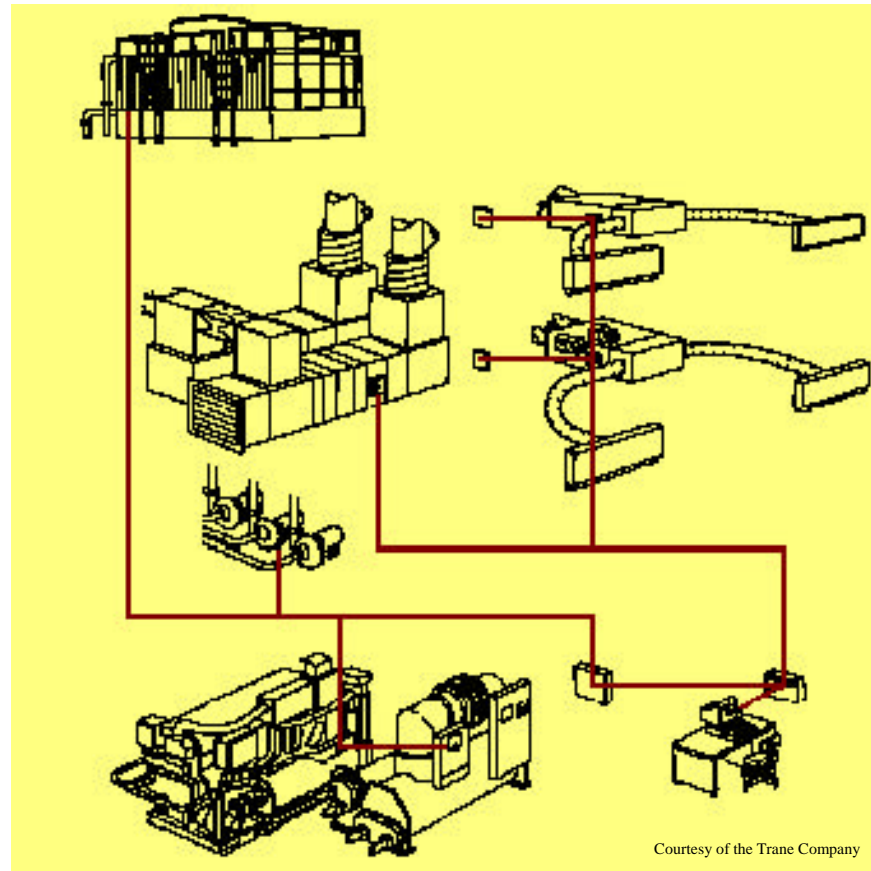
# How to Get the Standard



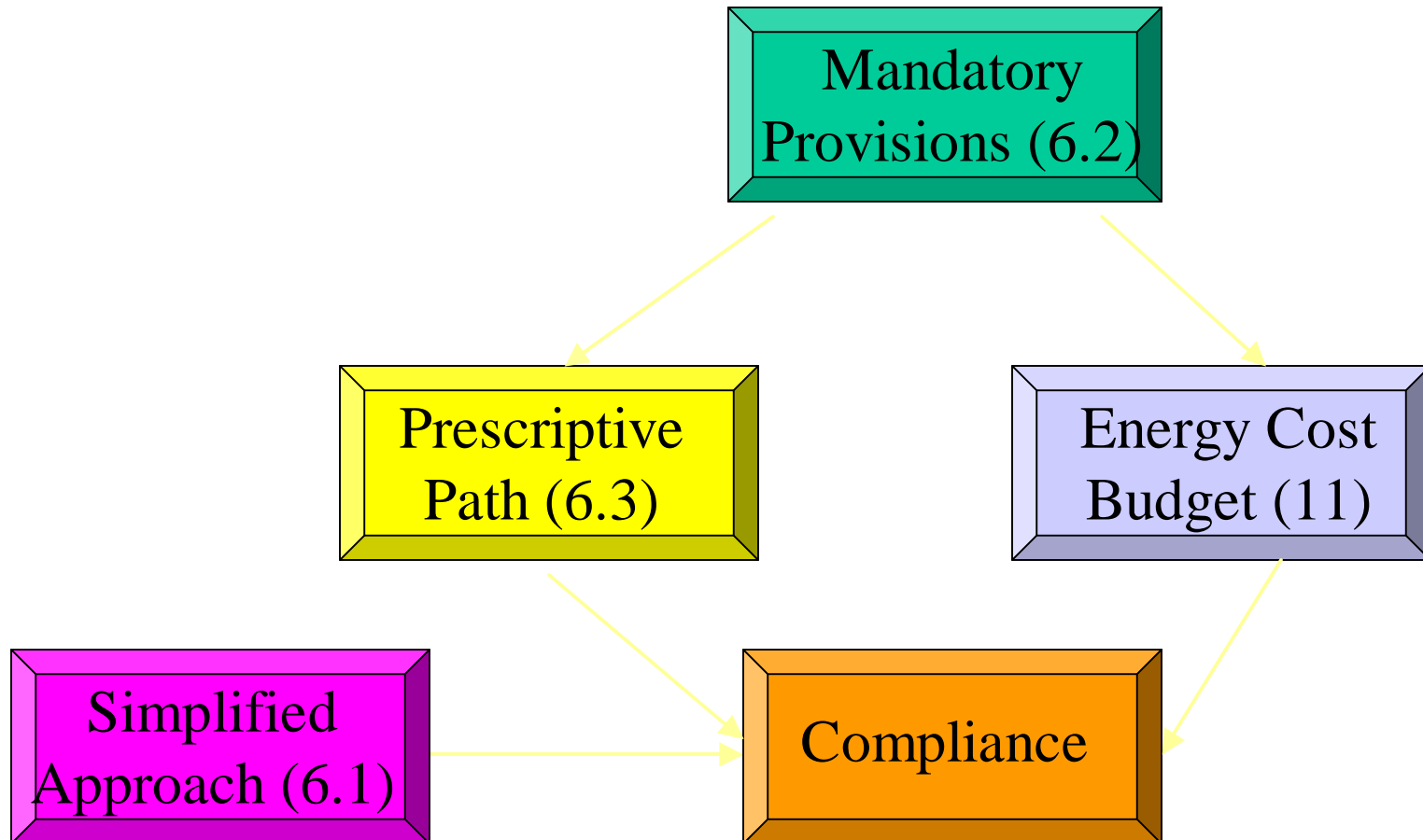
# Status of State Adoption



# HVAC and Service Water Heating

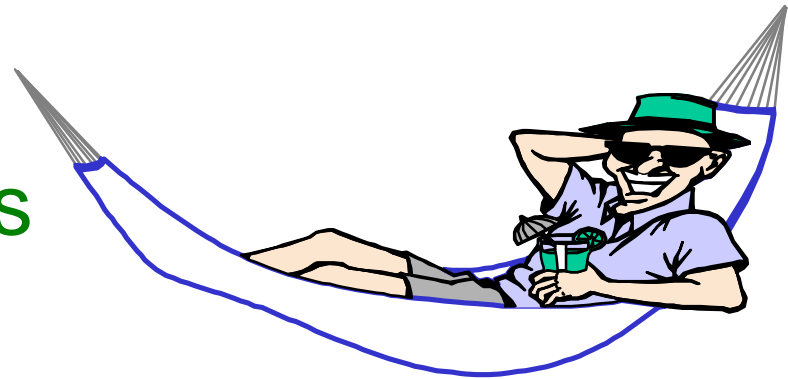


# Section 6 – HVAC Compliance



# Simplified Approach

- Purpose
- Same requirements
- Fits on two pages
- Limited to...
  - Buildings with 1 or 2 stories
  - Buildings < 25,000 ft<sup>2</sup>
  - Single-zone system
  - Air cooled or evaporatively cooled



## Simplified Approach (cont'd)

- Economizer as necessary
- Heat pump or fuel-fired furnace for heat
- OA < 3000 cfm, 70%
- Manual changeover of dual set-point thermostat
- If heat pump, auxiliary controls
- No reheat for humidity control
- Night setback controls (except hotel/motel)

## Simplified Approach (cont'd)

- Piping and ductwork insulated
- Balancing within 10% of design airflow rates
- Interlocked thermostats if heating and cooling equipment are separate
- Exhaust > 300 cfm, gravity or motorize dampers
- System > 10,000 cfm, optimum start controls



# Mandates – HVAC Section

## Requirements address...

Equipment efficiencies (6.2.1)

Load calculations (6.2.2)

Controls (6.2.3)

Construction and insulation (6.2.4)

Completion requirements (6.2.5)



Required in either Prescriptive or ECB  
compliance path

# Equipment Covered

## Tables 6.2.1a – 6.2.1g

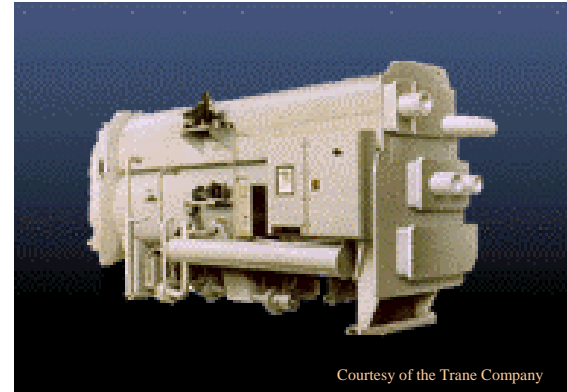
- Packaged air conditioners
- Heat pumps
- Chillers
- Packaged terminal/  
room air conditioners
- Furnaces
- Boilers
- Heat rejection equipment



Courtesy of the Trane Company

# Equipment Covered for the First Time

- Ground-source heat pumps
- Single- and double-effect absorption chillers
- Heat rejection equipment
- New categories for
  - Hot water and steam boilers
  - Replacement PTAC's and PTHP's



Courtesy of the Trane Company

# Furnace Requirements

- Gas-fired and oil-fired furnaces  
> 225,000 Btu/h
  - Intermittent ignition, or interrupted device
  - and either power venting or flue damper
- Furnaces 225,000 Btu/h
  - Jacket losses < 0.75% of the input rating

# Cooling Equipment *Examples*

Type	Efficiency as of 10/29/2001		
20-100 ton self-contained	11.0 EER*		
	10.3 IPLV*		
1.5 - 5.25 ton	12.0 EER	(cooling)	
water-source heat pump	4.2 COP	(heating)	
? 300-ton water-cooled centrifugal chiller (ARI Standard conditions)	6.10 COP	0.576 kW/ton	
	6.40 IPLV	0.549 IPLV	

\* Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat

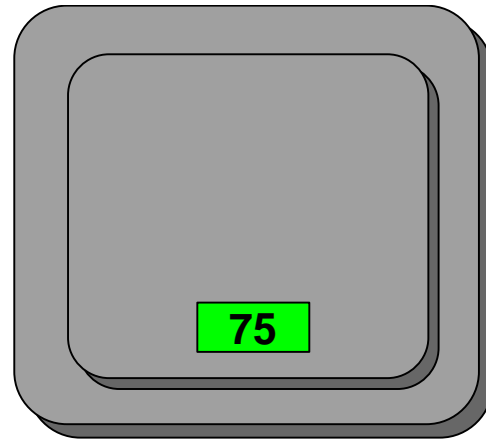
**Both full and part load efficiencies are required**

# Load Calculations

- No longer a sizing restriction
- Requires calculations to be done using generally accepted engineering standard handbooks

# Thermostatic Controls

- Required for each zone – perimeter can be treated differently
- 5°F deadband
  - Dual setpoint or deadpoint
  - [can be software for Direct Digital Control (DDC)]



# Thermostatic Controls

## Perimeter

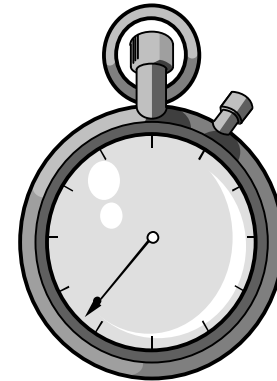
**Zone  
required  
for each of  
these long  
exposures**

**also for  
core**



# Off-Hour Controls > 65,000 Btu/h and $\frac{3}{4}$ hp

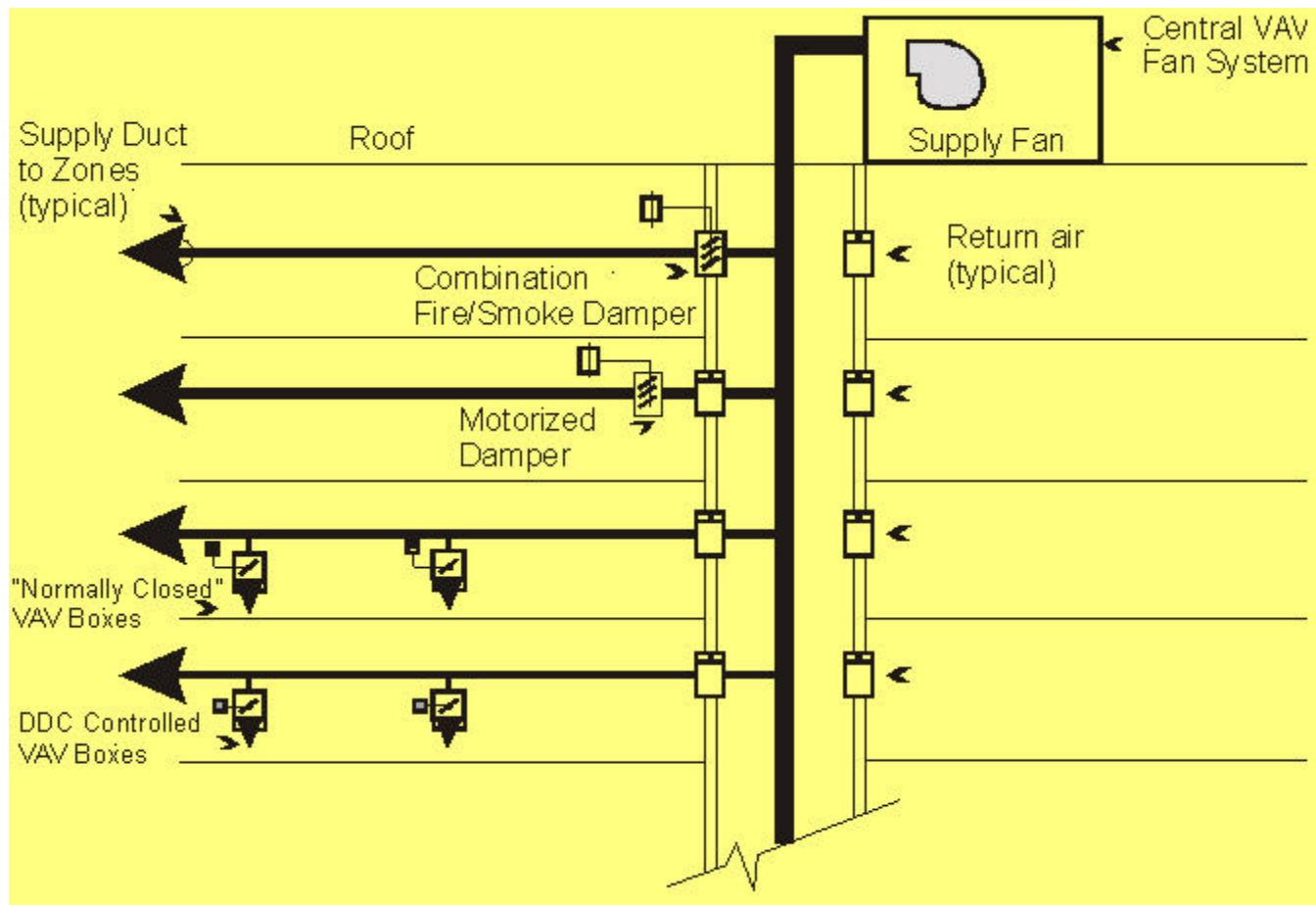
- Automatic Shutdown
  - Automatic time clock with 10 hour battery back up
  - Occupancy sensor
  - Manually operated timer with max. 2 hour duration
  - Security system interlock
- Setback, except radiant
- Optimum start > 10,000 cfm



# Off-Hours Controls (cont'd)

- Shut-off dampers controls
- Zone isolation
  - 25,000 ft<sup>2</sup> maximum zone size on one floor
  - Shut off airflow
  - Central systems capable of stable operation
- Exceptions, HVAC Systems
  - Serving hotel/motel guest rooms
  - Intended to operate continuously

# Zone Isolation Example

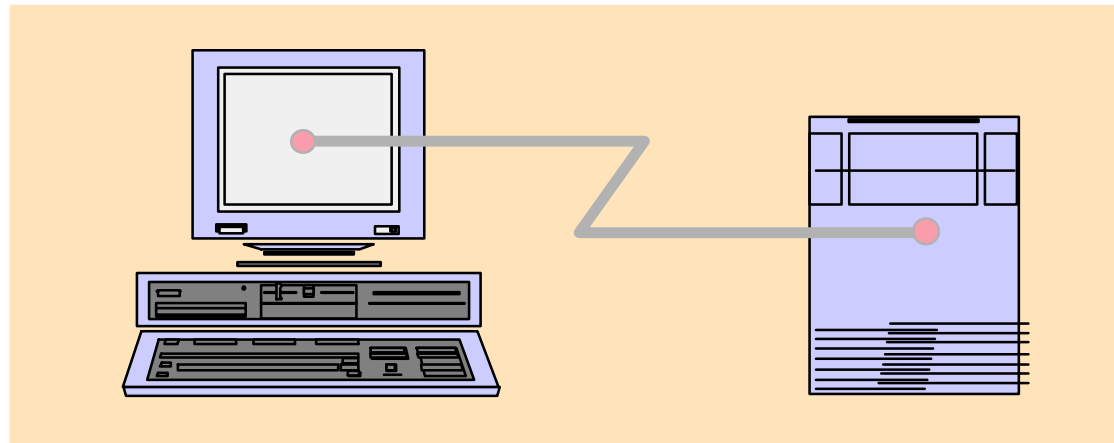


Courtesy of ASHRAE

# Heat Pump Auxiliary Heat Control

- Heat pump with internal electric heaters need to use heat pump alone when load can be met
- Exception:
  - Covered by NAECA and HSPF meets Table 6.2.1B including electric resistance heating

# This Requires *System* Level Controls

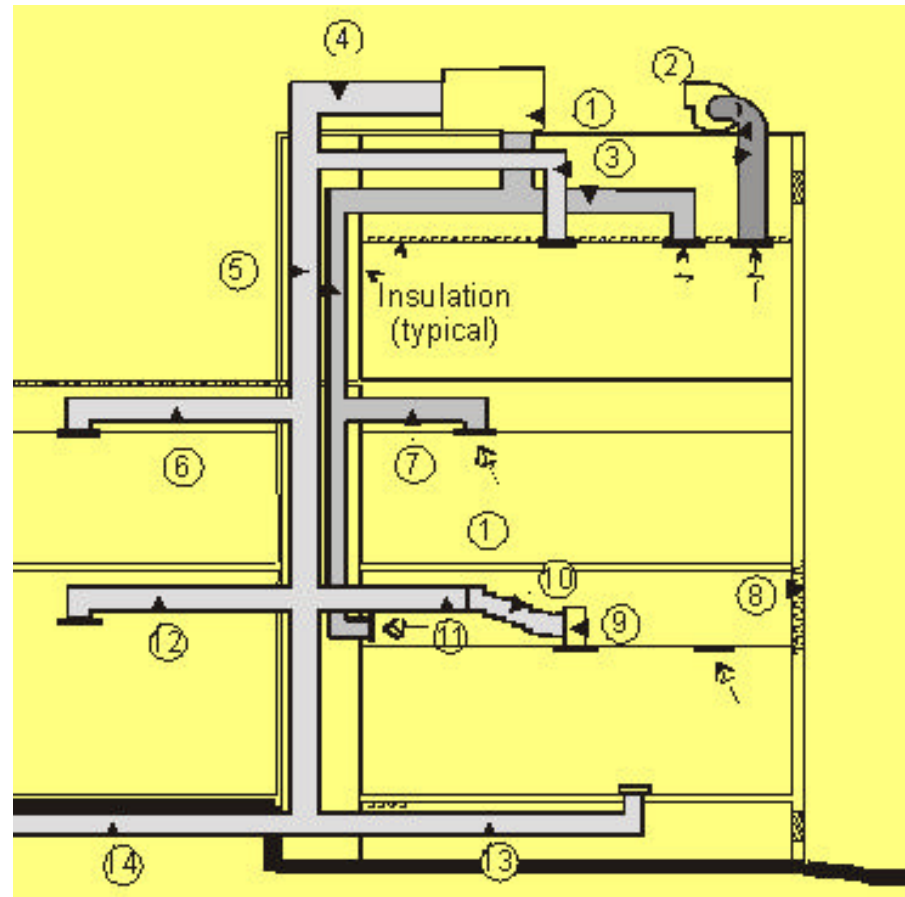


# Construction & Insulation

- Installed in accordance with industry standards
- “Durable” insulation
- Duct and plenum insulation
  - Separate or combined heating and cooling
  - Based on location
  - Based on life cycle costing
- Duct sealing



# Duct Insulation Example



Courtesy of ASHRAE

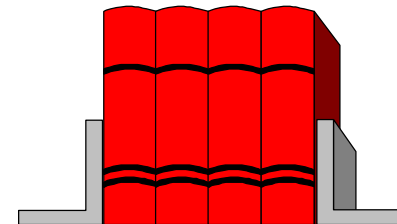
# Construction & Insulation (cont'd)

- Leakage tests (> 3 in. w.c.)
  - 25% tested
  - Maximum  $L = CLP 0.65$
- Piping Insulation
  - Based on life cycle costing
  - Exceptions:
    - Factory installed in equipment
    - Fluids 60° F
    - Unions in heating system



# Completion Requirements

- Within 90 days of acceptance
- Drawings
  - Equipment location and performance
  - Duct and piping configuration
  - Terminal air or water design flow rates
- Manuals
  - Operating
  - Maintenance



# Completion Requirements (cont'd)

- Balancing
  - Written report conditioned spaces > 5,000 ft<sup>2</sup>
  - In accordance with accepted practices
  - Airside > 1hp
  - Hydronic pumps >10 hp, measure ? P and trim impeller

# Completion Requirements (cont'd)

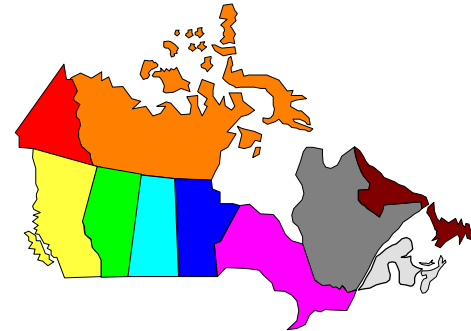
- Commissioning (see Appendix E)
  - Control elements calibrated, adjusted and in working order
  - $> 50,000 \text{ ft}^2$
  - Detailed instructions provided by designer

# HVAC Prescriptive Path – 6.3

- Requirements address...
  - Economizers
  - Simultaneous heating and cooling
  - Air system design and control
  - Hydronic system design and control
  - Heat rejection equipment control & limitations
  - Heat recovery
  - Exhaust hoods

# Economizer

- Climate and Size Dependent
- Up to 100% Outside air
- Numerous (9) exceptions
  - Efficiency trade-off, system size and climate change from 10.3 to 12.5 EER (CDD50)
  - Supermarket open refrigerated casework systems
- Integrated control
  - Start using when beneficial



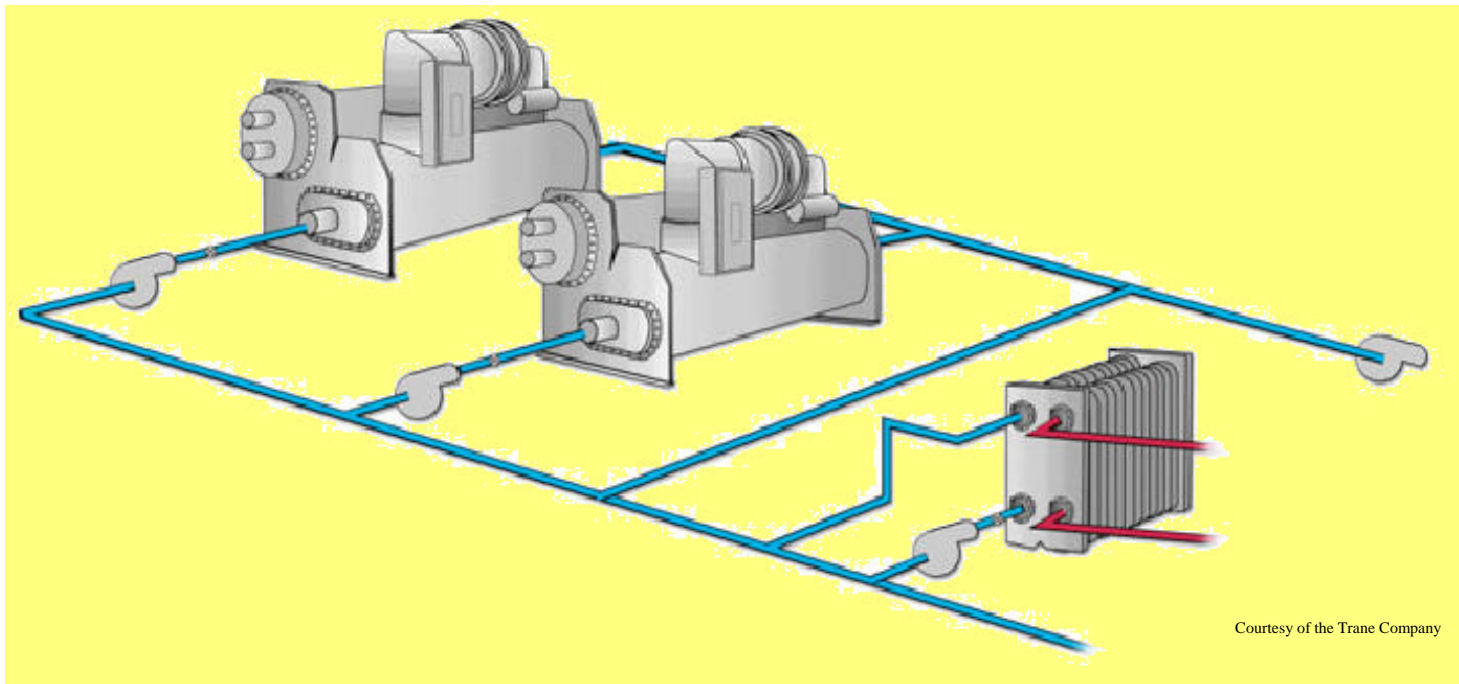
# Air Economizers

- High limit shutoff
- Reduce amount to ventilation requirements
- Prohibited control types
  - Dry climates – fixed enthalpy
  - Humid climates – differential dry bulb
- Damper leakage rate
- Pressure relief and re-circulation avoidance

## Economizers (cont'd)

- Waterside
  - Size requirement, 100% at 50/45  
Exception: if dehumidification needs can't be met, 45/40
  - Reduce pressure drop effect if  $>15$  ft
- Heating impact

# Waterside Economizer - Bypass Arrangement





No. of Hours Between 8 am and 4 pm with $55^{\circ}\text{F} < T_{\text{db}} < 69^{\circ}\text{F}$	1% Cooling Design Wet-Bulb Temperature		
	$T_{\text{wb}} < 69^{\circ}\text{F}$	$69^{\circ}\text{F} \leq T_{\text{wb}} \leq 73^{\circ}\text{F}$	$T_{\text{wb}} > 73^{\circ}\text{F}$
	Minimum System Size (Btu/h)	Minimum System Size (Btu/h)	Minimum System Size (Btu/h)
0 - 199	N.R.	N.R.	N.R.
200 - 399	135,000	N.R.	N.R.
400 - 599	135,000	N.R.	N.R.
600 - 799	65,000	135,000	N.R.
800 - 999	65,000	135,000	135,000
1000 - 1199	65,000	65,000	135,000
> 1199	65,000	65,000	65,000
N.R. means that there is no system size for which an economizer is a requirement in this climate.			

# Economizers – Example Requirements

Locale	1% Design WB	No. Hours 8 am – 4 pm 55<Tdb<69	System size at which economizer is required
Miami, FL	77	259	No economizer required
Evansville, IN	76	611	No economizer required
Chicago, IL	73	613	135,000 Btuh (11.25 tons)
New York, NY	73	790	135,000 Btuh (11.25 tons)
Denver, CO	59	739	65,000 Btuh (5.4 tons)
Boston, MA	71	713	135,000 Btuh (11.25 tons)
Minneapolis, MN	71	566	No economizer required
Tucson, AZ	65	716	65,000 Btuh (5.4 tons)
San Francisco,	62	1796	65,000 Btuh (5.4 tons)

# Simultaneous Heating & Cooling

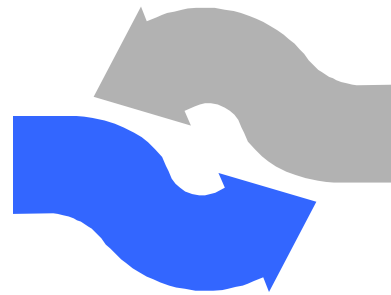
- Limits recooling, reheating or mixing
- Limited airflow per zone
- Hydronic systems
  - Three pipe not allowed
  - Two pipe changeover control
- Heat pump systems
  - Two-position valve

# Simultaneous Heating and Cooling Airflow Limits Per Zone

- Airflow limits
  - Standard 62 zone requirements, or...
  - 0.4 cfm/ft<sup>2</sup>, or...
  - 300 cfm, or...
  - Standard 62, 6-1 implementation
- Exceptions

# Simultaneous Heating and Cooling - Dehumidification

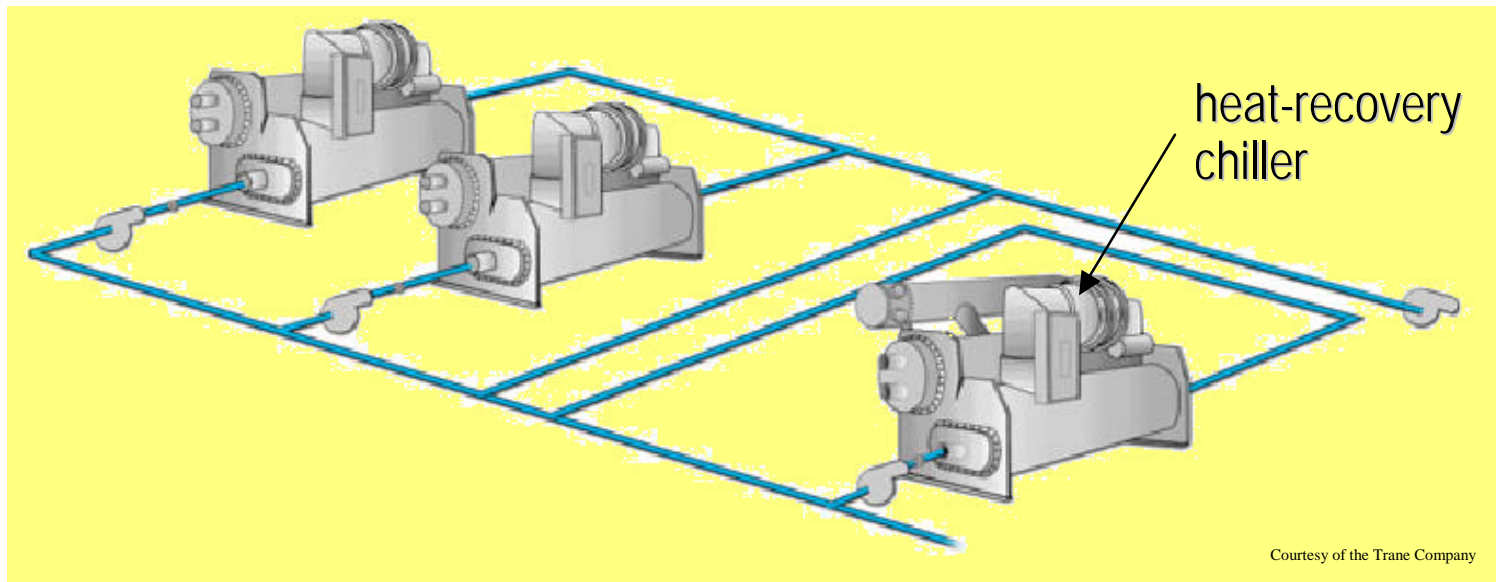
- Prevent
  - Reheating
  - Mixing of hot and cold air streams
  - Heating and cooling of same air stream



# Simultaneous Heating & Cooling – Dehumidification (cont'd)

- Exceptions
  - Reducing supply air flow to 50%, or minimum ventilation
  - Systems under 6.67 tons that can unload at least 50%
  - Systems smaller than 3.3 tons
  - Process applications
  - 75% of reheat or recool energy is site-recovered or site-solar

# Sidestream Configuration



# Humidification

- If inside dewpoint is  $> 35^{\circ}\text{F}$  and economizer is required then,
  - Must be water economizer



# Air System Design and Control

- Fan system power limitation
  - Applies to systems  $> 5$  hp
  - Limits based on nameplate hp of fans operating at design
  - Credits available for
    - Supply air temperatures below 55°F
    - Heat recovery pressure drops
    - Relief instead of return fan

# Air System Design and Control

## Fan System Power

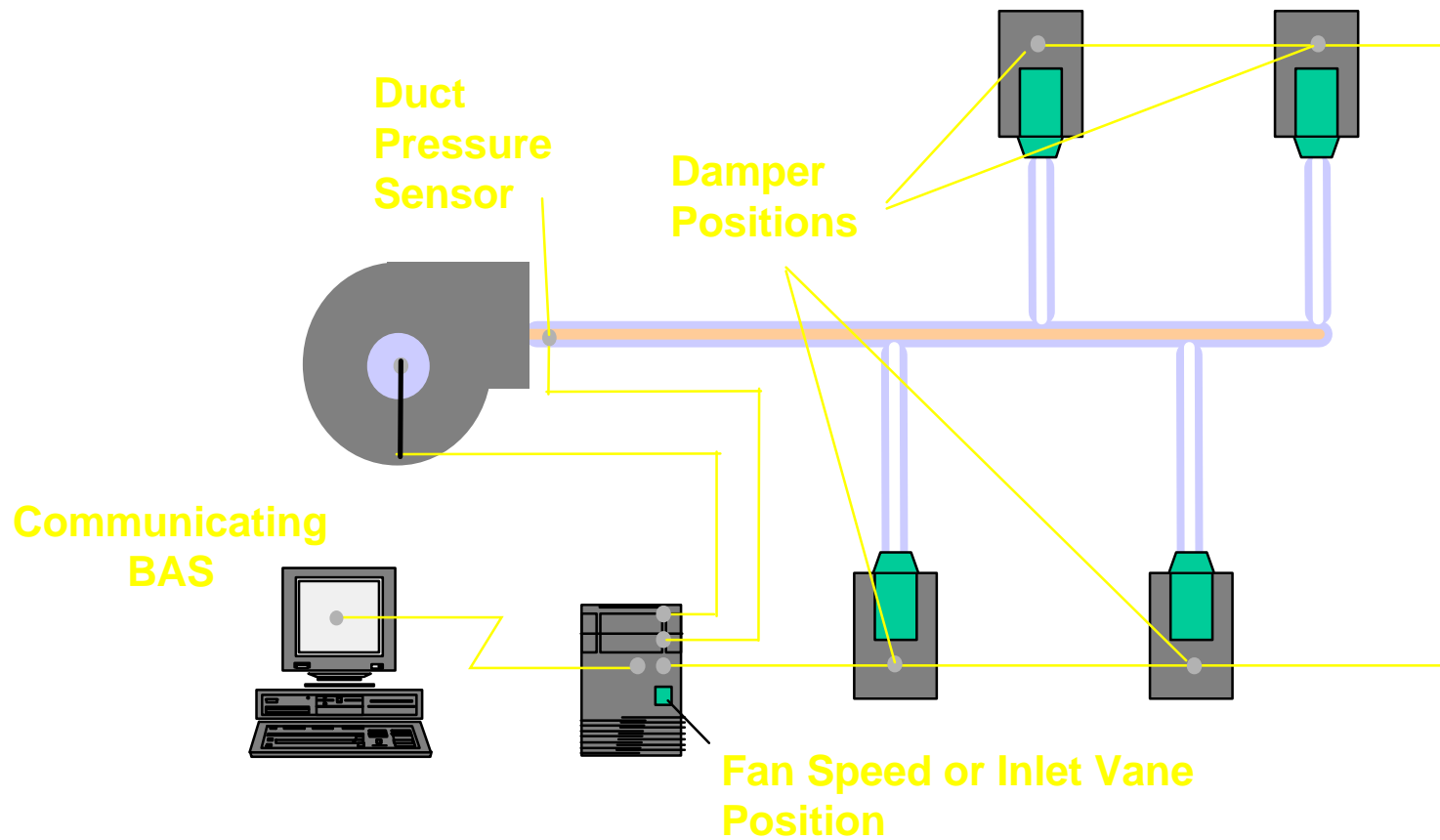
Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Volume	Variable Volume
< 20,000 cfm (9400 L/s)	1.2 hp/1000 cfm (1.9 kW/1000 L/s)	1.7 hp/1000 cfm (2.7 kW/1000 L/s)
? 20,000 cfm (9400 L/s)	1.1 hp/1000 cfm (1.7 kW/1000 L/s)	1.5 hp/1000 cfm (2.4 kW/1000 L/s)

# Air System Design and Control

- VAV fan control
  - Motors = 30 hp required to use 30% design wattage at 50% air volume
  - DDC: Set Point Reset required (Fan pressure optimization)



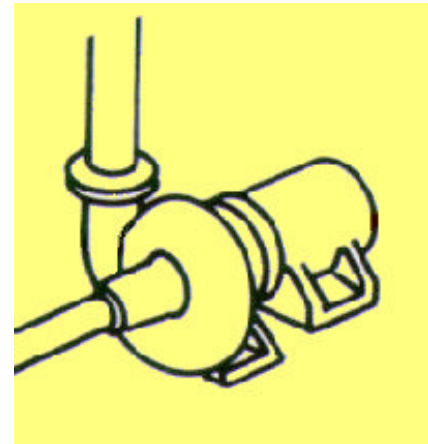
# Fan Pressure Optimization



Courtesy of the Trane Company

# Hydronic System Design and Control

- Above 10 hp
  - Hydronic variable flow system
  - Pump isolation
  - Chilled and hot water temperature reset
    - **Exception** – Not variable flow system



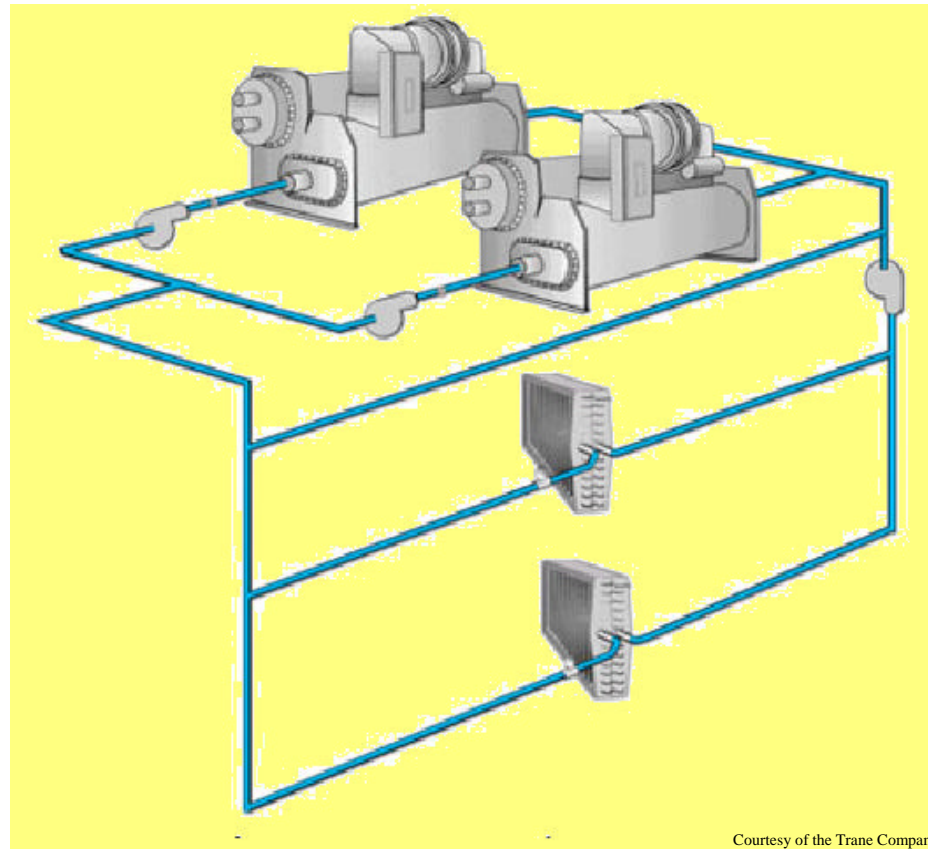
# Hydronic System Variable Flow Systems

- Variable flow required for systems
  - > 75 total hp
  - More than three control valves
- Individual variable flow pumps required when > 100 ft and 50 hp motor
  - 30% design wattage at 50% flow
  - Controlled as a function of flow or pressure differential

# Hydronic System Design and Control

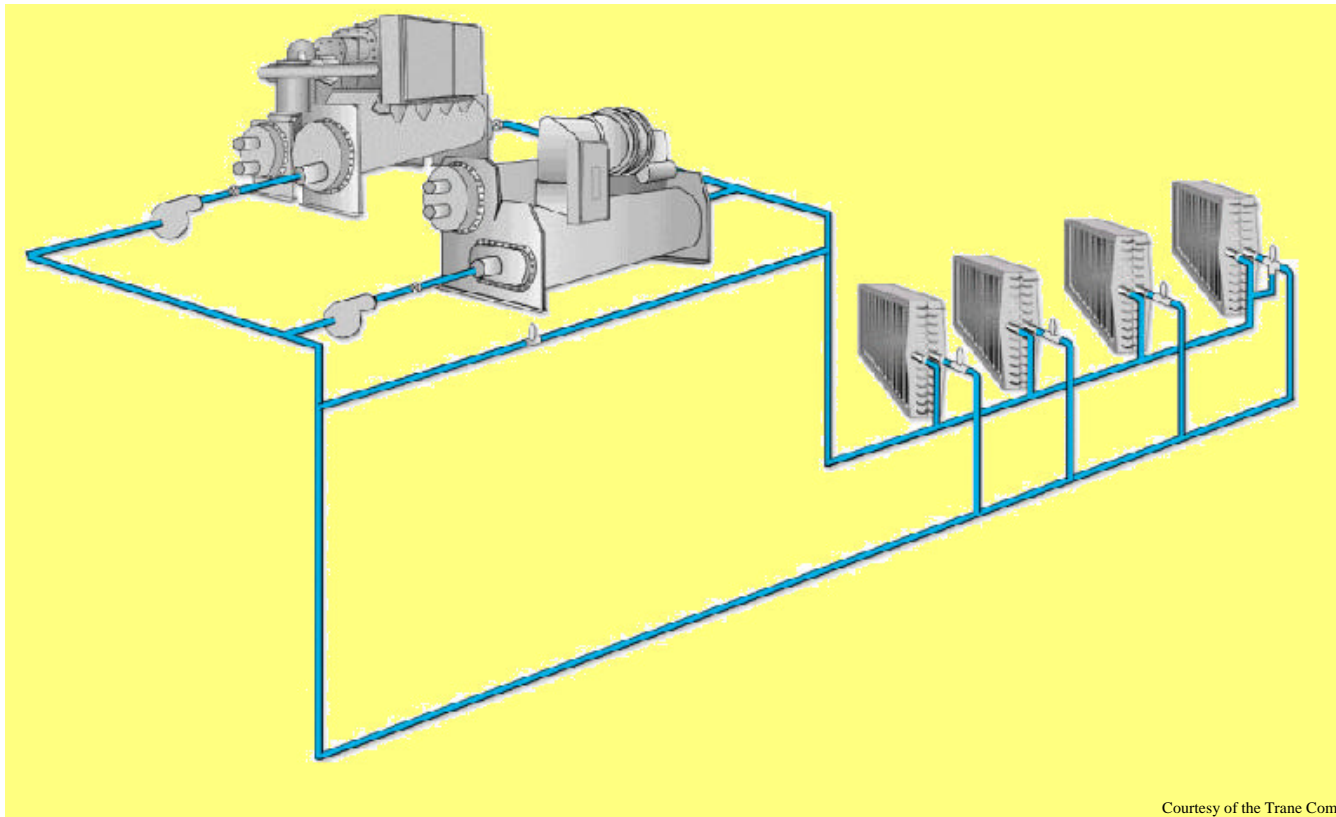
- Pump isolation
  - Series chillers considered as one chiller
  - Flow reduction when chiller or boiler shut down
- Chilled and hot water reset > 300,000 Btu/h
- **Exceptions:**
  - Result in improper operation
  - Variable flow systems that reduce pumping energy

# Primary-Secondary Configuration





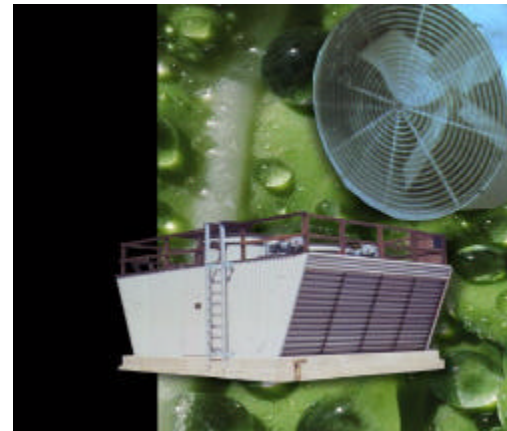
# Variable-Primary-Flow Systems



Courtesy of the Trane Company

# Heat Rejection Equipment

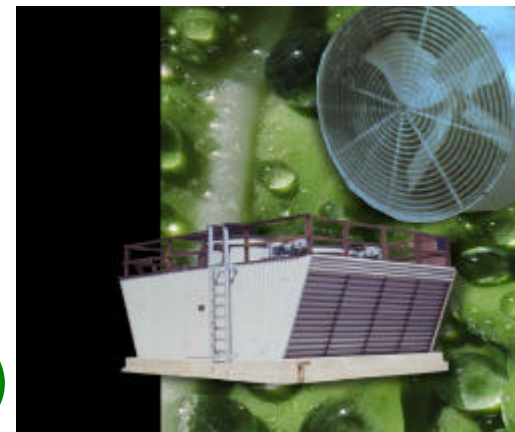
- Fan speed control 7.5 hp and up
  - Capability to operate at 2/3 speed or less
  - Change fan speed to control temperature or pressure



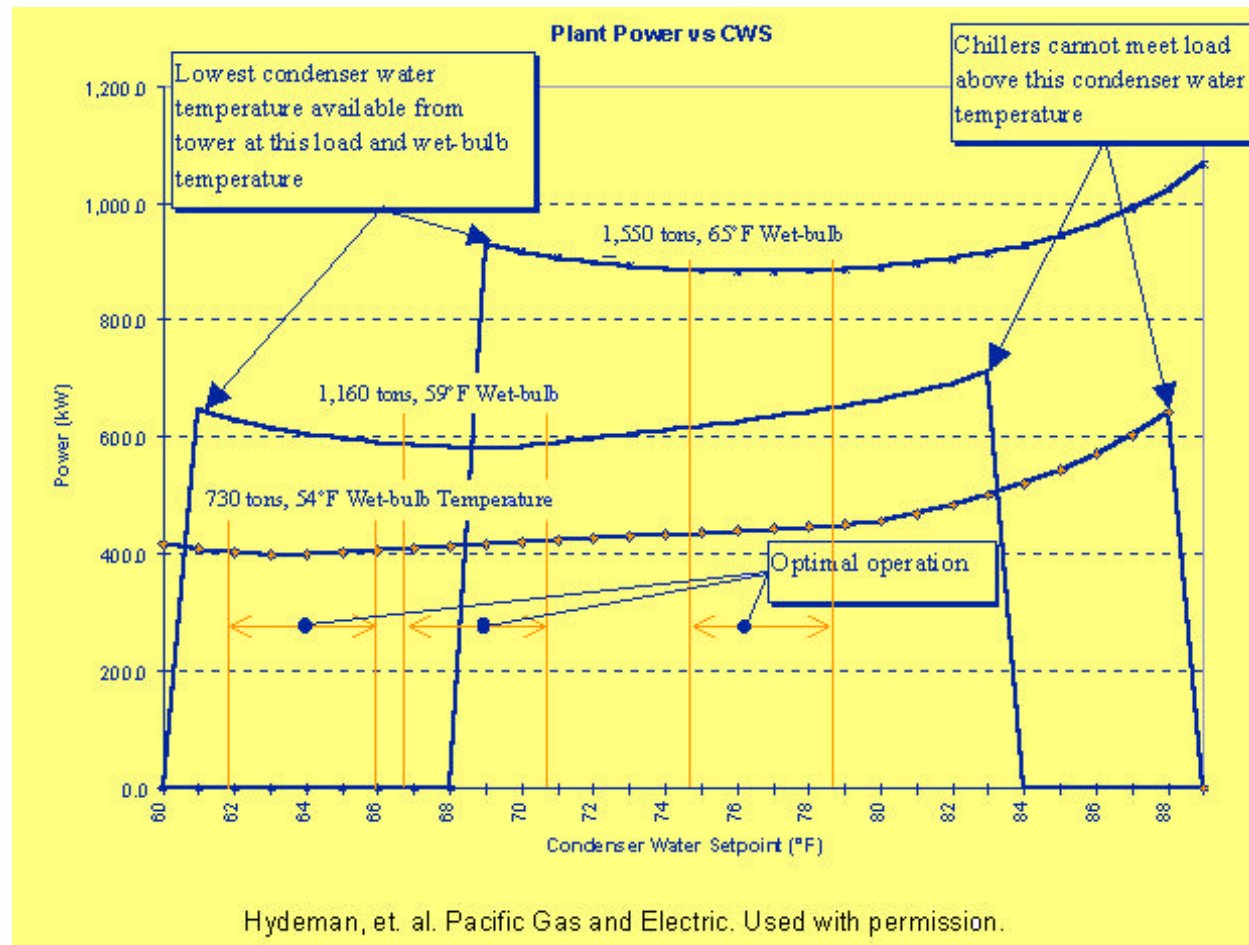
# Heat Rejection Equipment (cont'd)

- **Exceptions**

- Condenser fans on multiple circuits
- Condenser fans on flooded condensers
- Climates with a lot of cooling ( $> 7,200$  CDD50)
- 1/3 of the fans on a multiple fan application



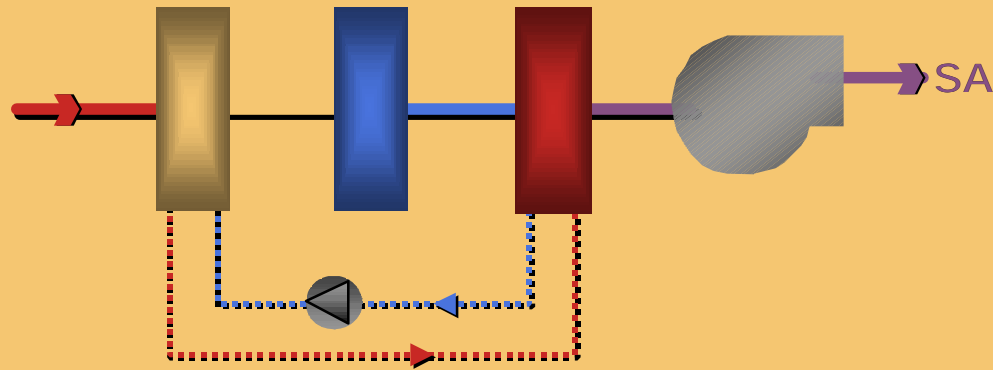
# Use of Fan Speeds



# Energy Recovery

- Airside
  - 70% OA and 5,000 cfm total
  - 50% effectiveness
- **Exceptions**
  - Contaminated exhaust
  - 60% of heating energy site recovered or solar
  - No exhaust airflow > 75% of outside airflow
  - Series heat recovery

# Series Energy Recovery



Courtesy of the Trane Company

# Energy-Recovery Technologies



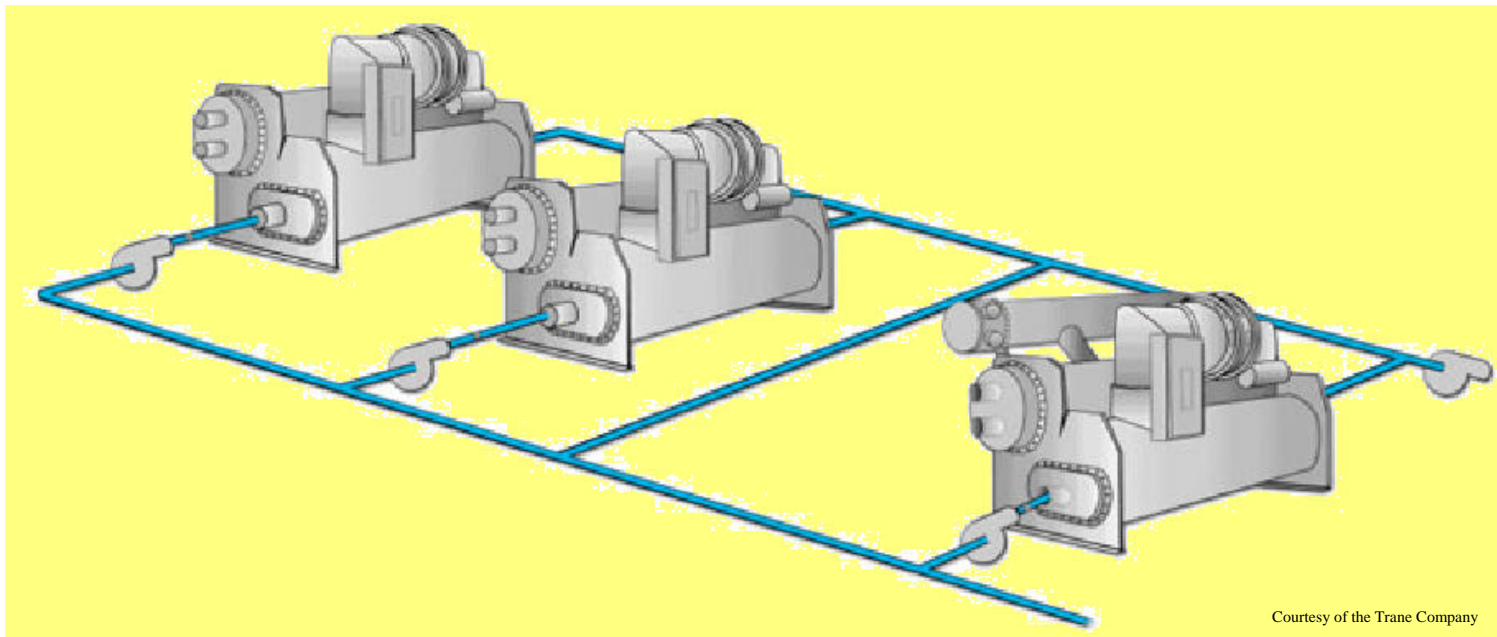
- Total-energy, rotary heat exchangers
- Membrane, fixed-plate heat exchangers

# Energy Recovery

- Service Water Heating
  - 24 hours per day and
  - Heat rejection  $> 6$  MMBtu/h and
  - SWH load 1 MMBtu/h
- Capacity is the smaller of
  - 60% of heat rejection
  - Preheat service hot water to 85°F



# Heat Recovery - Preferential Loading Configuration

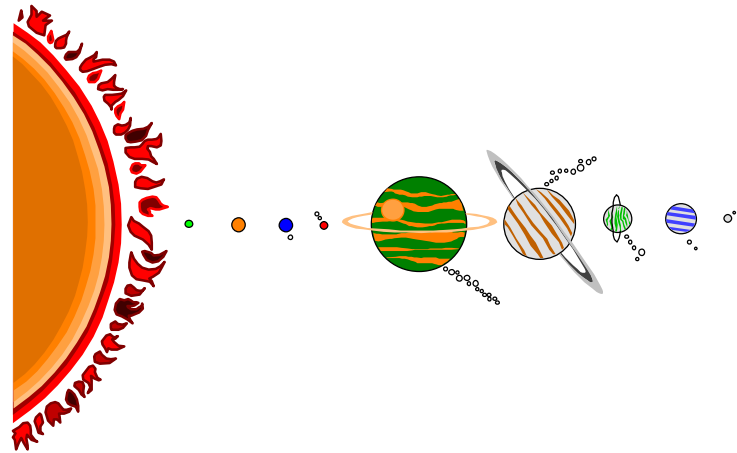


# Exhaust Hoods

- Kitchen hoods > 5,000 cfm
  - Make-up air 50% or more
    - Unheated or heated < 60°F
    - Uncooled or no mechanical cooling
- Fume hoods total > 15,000 cfm
  - Capability to < 50% or...
  - Direct make-up at least 75% of exhaust rate at specified conditions or...
  - Heat recovery for make-up air

# Radiant Heating

- Loading docks
- Unenclosed spaces



# Hot Gas Bypass Limitation

- > 7.5 tons
- Multiple steps or continuous unloading

Applies to chillers too

# Service Water Heating

- Efficiency
- Insulation
- Service water heating system controls
- Pool heaters and covers
- Prescriptive for
  - Space and water heating
  - Service water heating

# Questions?



# How to Get the Standard

